VARIATION OF SHORT-SCALE WAVES IN THE SHOALING ZONE

P.I.: Douglas Vandemark
NASA/GSFC
Laboratory for Hydrospheric Processes
Bldg. N-159
Wallops Island VA 23337
phone: (757) 824-2038 fax: (757) 824-1036 email: vandemark@gsfc.nasa.gov
Document Number: N00014-97-F-0179

LONG -TERM GOALS

Goals are to provide measurements of short-scale sea surface roughness in the shoaling wave zone, determine the correlation between this short-scale slope variance and surface wind stress, and finally suggest the ramifications to microwave remote sensing near the coast.

SCIENTIFIC OBJECTIVES

Primary objective is to determine the characteristics of near-vertical incidence millimeter-wave radar backscatter over the surf zone and out to sea using aircraft radar measurements collected from the NOAA Long-EZ. This radar information relates directly to an integration of the sea surface spectrum over wave scales from swell down to 1 cm but with heavy weighting towards horizontal scales less than a few meters. These short-scale waves are known to be well-coupled to the wind stress. We have also shown success in measuring the slopes of the intermediate scale gravity waves using a three laser ranging system aboard the aircraft. Thus our studies have expanded to addressing the correlation between intermediate and short scale wave characteristics and the atmospheric turbulence data collected using the LongEZ. This work falls under the Shoaling Waves Research Initiative with Jielun Sun being the primary group leader for these LongEZ activities. Our air and sea data are also being used to support RADARSAT SAR investigations of boundary layer signatures under the program of Pierre Mourad.

APPROACH

A simple down-looking Ka-band scatterometer (DLS) has been built and installed on the NOAA LongEZ research aircraft. High spatial resolution (< 1 m) radar backscatter data are being related to the small-scale surface slope using two-scale ocean scattering models. These measurements are highly complementary to the longer-wave slope data being derived from the LongEZ's laser sensors. Combined, the data can describe the variability of wave slope variance in the coastal zone. Knowledge of the slope variance is vital to the investigation of air-sea coupling and to proper understanding of scatterometer, SAR and radiometer measurements of the ocean surface.

WORK COMPLETED

More than 25 successful data collection missions were flown by the LongEZ in March and Nov. of 1999 as part of the Shoaling Waves Experiment (SHOWEX) conducted off of Duck N.C. High quality radar and laser altimeter data were obtained on all nearly flights and the data have been through initial processing. Some results from March 1999 have already been finalized and included in our initial paper (Sun et al., 2000) on the shoaling zone observations. Necessary internal and external calibration of the radar and final processing of the main Nov. 1999 experiment data are nearly complete at this time.

Substantial effort has gone into calibrating and analyzing the surface slope measurements made with the three laser altimeters aboard the Long-EZ. These lasers combine to provide a sort of vector slope gauge and the fidelity of the 2-D slope data is quite promising. A laboratory study of the laser performance under light wind conditions was undertaken at NASA's Wallops Flight Facility in summer 2000. An internal report was issued to all team members. In addition, we are now testing, in collaboration with M. Donelan of the Univ. of Miami, the capability of the system to derive 1 and 2-D long wave spectra from the lasers' wavenumber encounter spectral data.

RESULTS

Publications related to observed boundary layer roll vortex signatures, the general model for the non-Gaussian distribution of ocean wave slopes, and short wave observations near the coast have been produced. In particular, the results of Sun et al. (2000) provide a detailed look at the atmospheric turbulence near the coast and its variation with respect to on and off-shore wind flow. This study presents surface wave observations suggesting that the classical open-ocean short fetch model for wave generation may not apply in the case of off-shore flow within 5 km of the coast (for the case of Duck NC). For this special, yet common, case – the winds and friction velocity observed 10 to 20 m above the surface indicate a very high drag coefficient – an observation that is inconsistent with relatively smooth surface wave observations at both the long and short wave scales. We find that this close to shore the atmospheric turbulence is most clearly associated with advection from over the rough land surface and these eddies are decaying rapidly with off-shore distance towards a more recognizable and reasonable wind/wave coupling estimates after about 5-8 km. Shoaling during these off-shore flow events does not appear to be a major factor modifying the short-scale wave environment. For on-shore flow the observed air-sea interactions are much closer to previous open-ocean observations. Relatively small perturbations due to shoaling zone impacts are the subject of future study.

IMPACT

We expect the overall impact of these results to come in an improved understanding of how to better use microwave remote sensing in the shoaling zone.

TRANSITIONS

The radar data collected under this program are directly relevant to ongoing satellite altimeter research into the wind and sea state responses of that sensor. A Ku-band sensor of similar design to our small aircraft radar is now being developed for future program use by the Univ. of Michigan in conjunction with their development of collision avoidance radar for the automotive industry.

RELATED PROJECTS

As mentioned above, this work is directly related to the NOAA LongEZ shoaling zone activities headed by J. Sun (cf. Sun:N00014-0-98-1-0245, Mahrt:N00014-0-98-1-0282, and Crawford:N00014-97-F-0123). This work is also closely related to NASA's Office of Earth Science research efforts to improve estimation of ocean sea level and wind speed as extracted from satellite altimeters, scatterometers and radiometers.

PUBLICATIONS

Vandemark, D., P. D. Mourad, T. L. Crawford, C. A. Vogel, J. Sun, S. A. Bailey and B. Chapron, Measured changes in ocean surface roughness due to atmospheric boundary layer rolls, , J. Geophys. Res, in press.

Mourad P. D., D. R. Thompson and D.Vandemark, Extracting fine-scale wind fields from synthetic aperture radar images of the ocean surface, Johns Hopkins APL Technical Digest, 21(1), 108-115, 2000.

Sun J. , D. Vandemark , L. Mahrt, D. Vickers, T. L. Crawford and C. A. Vogel, Momentum transfer over the coastal zone, revision submitted to JGR-Atmospheres, Sept. 2000.

Chapron, B., V. Kerbaol, D. Vandemark, T. Elfouhaily, Importance of peakedness in sea surface slope measurements and applications, J. Geophys. Res., 105(C7), 17195-17202, 2000.